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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

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APPELLANTS: Mitsuhiro Nakamura, et al ATTY. REF: P97,0322
SERIAL NO.: 08/809,463 GROUP ART UNIT: 2814
FILING DATE: July 18, 1997 EXAMINER: N. Kelley
TITLE: "MULTI-LAYERED STRUCTURE FOR FABRICATING AN OHMIC
ELECTRODE AND OHMIC ELECTRODE"

Assistant Commissioner for Patents
Washington D.C. 20231

APPELLANTS' APPEAL BRIEF TRANSMITTAL LETTER

Dear Sir:

Appellants are submitting herewith, in triplicate, Appellants' Appeal Brief in support of the Notice of Appeal mailed to the Patent Office on February 19, 1999. A check in the amount of \$300.00 for the requisite fee for filing the Appeal Brief is attached hereto. Appellants hereby request a four month extension of time for filing this Appeal Brief so that the time for responding is extended from April 19, 1999 to August 19, 1999. A check in the amount of \$1,360.00 for this extension fee is attached hereto. Please charge any additional fees that may be due and owing or credit any overpayment to Deposit Account No. 08-2290. A duplicate copy of this sheet is enclosed.

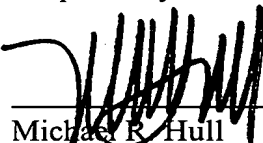
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Respectfully submitted,

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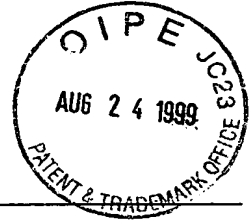
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I hereby certify that this correspondence for Serial No. 08/809,463 is being deposited with the United States Postal Service as First Class Mail in an envelope addressed to:

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on August 19, 1999

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ELECTRODE AND OHMIC ELECTRODE"

Assistant Commissioner for Patents
Washington D.C. 20231

APPELLANTS' APPEAL BRIEF

Dear Sir:

Appellants submit this Appeal Brief in furtherance of the Notice of Appeal mailed to the Patent Office on February 19, 1999. The Appeal was taken from the Final Rejection dated August 19, 1998.

I. REAL PARTY IN INTEREST

Sony Corporation is the real party in interest in this appeal by virtue of an executed Assignment recorded in the United States Patent and Trademark Office on April 21, 1997, at Reel 8628, Frame 661.

II. RELATED APPEALS AND INTERFERENCES

No other Appeals or Interferences are known to Appellants, Appellants' legal representative or Assignee.

III. STATUS OF THE CLAIMS

Claims 1-19 are pending in the patent application. A copy of these claims is appended hereto as the Appendix. The Final Rejection rejects Claims 1-19. A copy of the Final Rejection is appended hereto as Exhibit A of the Supplemental Appendix.

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IV. STATUS OF THE AMENDMENTS

No amendment was filed after the Final Rejection mailed August 19, 1998. Accordingly, all amendments have been entered in this application.

V. SUMMARY OF THE INVENTION

This application relates to a multi-layered structure for fabricating an ohmic electrode, particularly an ohmic electrode suitable for III-V compound semiconductors. The present invention provides an ohmic electrode of high performance and reliability based on its improved and unexpected properties of thermal stability and a low contact resistance. (Page 1, lines 10-14.) Due to a sequentially layered arrangement of a non-single crystal semiconductor layer and a film layer, including at least a metal nitride film atop of a III-V compound semiconductor substrate layer, the new and improved thermal and contact resistance properties can be obtained. (Page 7, lines 2-6.)

Specifically, the present invention is directed to a multi-layered structure for fabricating an ohmic electrode having practically satisfactory characteristics for GaAs semiconductors and other III-V compound semiconductors. (Page 7, lines 8-13.) First, the application provides a multi-layered structure. This structure includes a non-single crystal semiconductor layer, a film including at least a metal nitride film, and a III-V compound semiconductor substrate. The non-single crystal and film layers are sequentially stacked on the III-V compound semiconductor substrate. (Page 7, lines 8-13.) Second, the present invention further provides a multi-layered structure wherein the energy barrier between the non-single crystal semiconductor layer and the film layer is lower than the energy barrier between the III-V compound semiconductor body and the film. (Page 7, lines 14-22.) Third, the present invention provides an ohmic electrode by annealing the multi-layered structure. (Page 7, lines 23-27; page 8, line 1.) Fourth, the present

invention further provides an ohmic electrode obtained by annealing the multi-layered structure wherein the energy barrier between the non-single crystal semiconductor layer and the film layer is lower than the energy barrier between the III-V compound semiconductor substrate and the film. (Page 8, lines 2-12.)

In addition, the individual layers of the multi-layered structure are further characterized as follows. First, the III-V compound semiconductor body may include GaAs, AlGaAs or InGaAs. (Page 8, lines 13-15.) Next, the non-single crystal semiconductor layer may include an InGaAs compound as further characterized by the formula $\text{In}_x\text{Ga}_{1-x}\text{As}$ ($0 < x \leq 1$). (Page 8, lines 23-25.) Further, the film layer may be layered between the III-V compound semiconductor substrate and the non-single crystal layer for the purpose of improving the affinity of the non-single crystal layer to the III-V compound substrate. (Page 9, lines 13-17.) In one typical embodiment, the film layer may include both a metal film and a metal nitride film wherein the metal nitride film is layered atop of the metal film. The metal film is utilized for the purpose of annealing at a lower temperature in order to make the ohmic electrode with a low contact resistance. Moreover, the metal nitride film provides the distinct advantage of preventing elements of the non-single crystal semiconductor layer from diffusing toward the electrode surface during annealing. (Page 9, lines 17-26; page 10, lines 1-2.) Furthermore, a refractory metal film may be layered onto the metal nitride film for such purposes as reducing the sheet resistance of the ohmic electrode and permitting the metal wiring to be connected to the ohmic electrode without the need for a barrier metal. (Page 10, lines 3-8.) The metal film, metal nitride film and refractory metal film may be further characterized as follows: 1) the metal film may include Ni, Co or Al; 2) the metal nitride film may include WN, WSiN, TaN, TaSiN, Ti, TiSiN, or TiON and 3) the refractory metal film may include W, Ta or Mo. (Page 10, lines 10-22.)

According to the present invention, a high performance and reliable ohmic electrode, exhibiting practically satisfactory characteristics, such as thermal stability, low contact resistance and flatness of the surface, can be easily fabricated by annealing the above described multi-layered structure at a temperature ranging from 500°C to 600°C. (Page 11, lines 16-23.)

To provide direction to one of skill in the art, pages 13-26 of the specification set forth five embodiments of the present invention. The embodiments specifically detail the make-up of the multi-layered structure and how the structure may then be formed by the annealing process resulting in a thermally stable and low contact resistance ohmic electrode. The improved and unexpected low contact resistance and thermal stability properties are evidenced in Figures 5 and 7 and further discussed on pages 16-19 of the specification.

VI. ISSUES

The issues on Appeal are:

1. Are Claims 1, 2, 3, 4, 7, 9, 10, 11, 12, 13, 14, 17 and 19 unpatentable under 35 U.S.C. §103(a) as obvious over U.S. Patent No. 5,098,859 ("*Jackson et al*") in view of DE 41 29 647 A1 ("*Nirschl et al*")?

2. Are Claims 5, 6, 8, 15, 16 and 18 unpatentable under 35 U.S.C. §103(a) as obvious over *Jackson et al*, *Nirschl et al* and further in view of JP 59-66166 ("*Ishihara et al*")?

VI. GROUPING OF THE CLAIMS

Appellants argue for the patentability of the dependent Claims 5, 6, 8, 15, 16 and 18 separate and apart from the independent claims from which they depend.

VIII. ARGUMENT

A. The Claimed Invention

The present invention provides a multi-layered structure for fabricating an ohmic electrode exhibiting unexpected and improved properties of thermal stability and low contact resistance. The present application contains four independent claims, namely Claims 1, 9, 10 and 19.

Claim 1 is directed to a multi-layered structure for fabricating an ohmic electrode. The multi-layered structure requires a non-single crystal semiconductor layer and a film layer. The non-single crystal and film layers are sequentially stacked on a III-V compound semiconductor body. The non-single crystal semiconductor layer comprises In, and the film layer includes at least a metal nitride film. Claims 2-8, directly or indirectly, depend from Claim 1.

Claim 5 is dependent upon Claim 4 and further defines the metal nitride film. Specifically, Claim 5 requires a refractory metal film that is further provided on the metal nitride film.

Claim 6 is dependent upon Claim 5 and further defines the refractory metal film. Specifically, Claim 6 requires that a further metal film for wiring is provided on the refractory metal film.

Claim 8 is dependent upon Claim 5 and further defines the refractory metal film. Specifically, Claim 8 requires that the refractory metal film is W, Ta or Mo.

Claim 9 is directed to a multi-layered structure for fabricating an ohmic electrode as required by independent Claim 1. Claim 9 further provides that the energy barrier between the non-single crystal and film layer is lower than the energy barrier between the III-V compound substrate and film.

Claim 10 is directed to an ohmic electrode obtained by annealing a multi-layered structure for fabricating an ohmic electrode as required by independent Claim 1. Claims 11-17, directly or indirectly, depend from Claim 10.

Claim 15 is dependent upon Claim 10 and further defines the metal nitride film. Specifically, Claim 15 requires a refractory metal film that is further provided on the metal nitride film.

Claim 16 is dependent upon Claim 15 and further defines the refractory metal film. Specifically, Claim 16 requires a further metal film for wiring that is provided on the refractory metal film.

Claim 18 is dependent upon Claim 15 and further defines the refractory metal film. Specifically, Claim 18 requires that the refractory metal film is W, Ta, or Mo.

Lastly, Claim 19 is directed to an ohmic electrode provided on a III-V compound semiconductor body and obtained by annealing a multi-layered structure for fabricating the ohmic electrode as required by independent Claim 1. Claim 19 further provides that the energy barrier between the non-single crystal and film layer is lower than the energy barrier between the III-V compound semiconductor substrate and film.

B. The Rejection

The Final Rejection rejects the pending claims based on three references. Specifically, the claims are rejected as obvious over the following references taken in combination: *Jackson et al*; *Nirschl et al*; *Ishihara et al*. According to the Examiner, these references, taken in combination, teach a multi-layered structure for fabricating an ohmic electrode wherein the multi-layered structure is made up of a III-V semiconductor body, a metal layer and a non-single

crystal semiconductor layer. Copies of these references are attached hereto as Exhibit B of the Supplemental Appendix.

Specifically, the Examiner asserts the references provide the following teachings. The *Jackson et al* reference teaches an improved contact to a III-V compound semiconductor body, namely GaAs. The improvement includes a non-single crystal semiconductor layer comprising In formed atop the III-V compound semiconductor body. *Jackson et al* completes this structure by forming a layer of metal atop the non-single crystal. With respect to the metal layer, the Examiner further asserts that "the metal is not critical and any metal will make a good contact" as stated in *Jackson et al*. However, the Examiner does recognize that the *Jackson et al* fails to teach the claimed upper metal layer of independent claims 1, 9, 10 and 19.

In the §103 rejection of Issue 1, the Examiner attempts to supplement the *Jackson et al* reference with the secondary reference, namely *Nirschl et al*. The Examiner asserts that *Nirschl et al* teaches an improvement to a metal contact made upon a III-V semiconductor layer. This improvement includes a first metal layer (2) formed atop a III-V body. A metal nitride layer (5), an adhesion promoting layer (6) and a final metal layer (4) sequentially follow. Based on these combined teachings, the Examiner maintains that one skilled in the art would have been motivated to form the *Jackson et al* upper metal layer in the manner taught by *Nirschl et al* because the *Nirschl et al* upper layer discloses an improved metal contact to a III-V compound semiconductor body, which is the function of the *Jackson et al* upper metal layer.

Regarding the §103 rejection of Issue 2, the Examiner attempts to supplement both the *Jackson et al* and *Nirschl et al* teachings with another secondary reference, namely *Ishihara et al*. The Examiner relies on the *Ishihara et al* reference only for its teaching regarding the use of Ti as an adhesion layer in a multi-layer contact structure. The Examiner maintains that the

Nirschl et al description of the layer solely in terms of its adhesive property coupled with *Ishihara et al's* successful use of Ti as an adhesive layer in a multi-layer structure provides sufficient motivation to one skilled in the art to use titanium and the adhesive layer in the collectively taught structure. (See Final Rejection, pages 3-4.)

C. The Cited Art Fails to Suggest the Features of the Claimed Invention

Appellants submit that none of claims are rendered obvious by any of the cited references. The cited references, taken alone or in combination, fail to teach or suggest the features of the claimed invention, namely a non-single crystal semiconductor including In, a film including at least a metal nitride film and a refractory metal film.

1. The Examiner has failed to make out a *prima facie* case of obviousness

Appellants respectfully submit the Examiner has failed to present a *prima facie* case of obviousness. In rejecting claims under 35 U.S.C. §103, the Examiner bears the initial burden of presenting a *prima facie* case of obviousness. *In re Rijckaert*, 9 F.3d 1531, 1532 (Fed. Cir. 1993). "A *prima facie* case of obviousness is established when the teachings from the prior art itself would appear to have suggested the claimed subject matter to a person of ordinary skill in the art." *Id.*

At the outset, Appellants submit that one of skill in the art would not be motivated to combine the cited references as asserted by the Patent Office. Of course, the Examiner "cannot pick and choose among the individual elements of assorted prior art references to create the claimed invention." *Diagnostic, Inc. v. Helena Laboratories Corp.*, 859 F.2d 878,887 (Fed. Cir. 1988). Instead, unless the prior art suggests the desirability of a modification, the mere fact that the prior art could be modified does not make the modification obvious. *In re Gordon et al*, 733 F.2d 900,902 (Fed. Cir. 1984).

Here, the Examiner appears to simply select individual components of the claimed invention from the different cited references. For example, the Examiner admits that *Jackson et al* neither teaches the metal nitride layer nor the adhesion layer formed of a refractory metal. For this reason, the Examiner attempts to combine *Jackson et al* with the secondary references, namely *Nirschl et al* and *Ishihara et al*. However, even assuming that *Nirschl et al* teaches the use of a metal nitride film and *Ishihara et al* teaches the use of a refractory metal film, Appellants question how one of skill in the art would be motivated to combine the teachings of the primary and secondary references.

After all, neither of the secondary references even relate to providing a non-single crystal layer comprising In in a multi-layered structure. For example, *Nirschl et al* only relates to improving the metal contact in a higher band gap compound semiconductor material, namely one that has a GaP semiconductor substrate. In contrast, the primary reference focuses on improving the metal contact in devices that incorporate a lower band gap semiconductor material (i.e. InSb or InAs) between the metal and the higher band gap compound semiconductor (see col. 1-2). Thus, Appellants question why one of skill in the art would even look to *Nishchl et al* (or *Ishihara et al*) in an attempt to modify the primary reference since it does not even relate to the same type of semiconductor.

Of course, utilizing Appellants' own disclosure as a template to combine the references together constitutes impermissible hindsight. Thus, absent at least some motivation or suggestion in the art itself, Appellant respectfully submits that one of skill in the art would not combine *Jackson et al* and *Nirschl et al* or alternatively *Jackson et al*, *Nirschl et al* and *Ishihara et al* as suggested by the Patent Office.

Furthermore, Appellants respectfully submit that the Patent Office has failed to provide the necessary teaching with respect to dependent Claims 8 and 18. The mere assertion that the refractory metals of Claims 8 and 18 would have been obvious based on routine engineering, design, optimization and implementation considerations does not displace the burden under 35 U.S.C. §103. Indeed, in rejecting claims based on implicit teachings or suggestions in the art, the Patent Office must produce a reference supporting such teachings. *In re Yates*, 663 F.2d 1054 (C.C.P.A. 1981).

2. **The cited references do not suggest the claimed invention**

Appellants also submit that the cited references do not provide the necessary suggestion to one of skill in the art for the claimed invention as required by independent Claims 1,9,10 and 19. Even if the primary reference relates to a multi-layered structure for fabricating an ohmic electrode, the references still do not teach all of the features of the claimed invention. Again, each of the independent claims require that the multi-layered structure contains both a non-single crystal semiconductor layer and a film layer including at least a metal nitride film.

In contrast, the *Jackson et al* reference merely relates to a semiconductor device wherein an InAs crystal is formed on a GaAs body. As even recognized by the Examiner, this reference does not provide any teaching or suggestion whatsoever regarding Applicants' claimed metal nitride film. This nitride film provides a significant advantage for the ohmic electrode of the claimed invention. Specifically, it prevents elements, such as In, constituting the non-single crystal semiconductor layer from diffusing toward the electrode surface during annealing. (page 9, line 25; page 10, lines 1-2.)

Indeed, the *Jackson et al* reference fails to even recognize this problem being addressed with the claimed invention. The fact that the art fails to consider the problem faced by the

inventor is indicative of non-obviousness. *See Diversitch Co. v. Century Steps, Inc.*, 850 F.2d 675, 679 (Fed. Cir. 1988).

Moreover, the secondary references do not remedy the deficiencies of the primary reference. As noted above, the *Nirschl et al* reference does not even relate to a semiconductor device that utilizes both a low and high band gap semiconductor material. The *Nirschl et al* reference fails to disclose whatsoever a non-single crystal layer comprising indium. Appellants have demonstrated in Figures 5 and 7 that the utilization of a non-single crystal layer results in a high performance and reliable ohmic electrode exhibiting thermal stability and low contact resistance. Likewise, the *Ishihara et al* reference does not disclose the use of a non-single crystal semiconducting layer nor does it teach a metal nitride film layer. The Examiner merely relies on *Ishihara et al* for teaching of the use of Ti as an adhesion layer in a multi-layer contact structure. However, absent the necessary connection between the references that would motivate one of look to such secondary references, Appellants respectfully the references fail to suggest the claimed invention.

For these reasons, Appellants respectfully submit that not only has the Examiner failed to make out a *prima facie* case of obviousness, the cited references simply do not suggest the claimed invention as required by independent Claims 1, 9, 10 and 19. Accordingly, Appellants respectfully request that the Board reverse the rejection of the pending claims under 35 U.S.C. §103.

**3. The cited references similarly fail to teach or suggest the
 claimed invention as recited in certain dependent claims**

Appellants further submit that the cited references do not provide the necessary suggestion to one of skill in the art for the claimed invention as required by dependent Claims 5, 6, 8, 15, 16 and 18. These dependent claims all recite the limitation of the refractory metal

film. The use of the refractory metal film provides distinct advantages, such as reducing the sheet resistance of the ohmic electrode and permitting metal wiring to be connected to the ohmic electrode without the need for a barrier metal. (page 10, lines 2-7.)

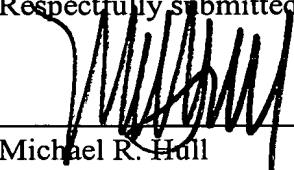
As noted by the Patent Office, neither *Jackson et al* nor *Nirschl et al* teach or suggest the refractory metal film layer. Further, Applicants respectfully submit that the Examiner's attempt to supplement *Jackson et al* and *Nirschl et al* with *Ishihara et al* fails because there is no suggestion to combine these teachings as previously discussed. In addition, *Ishihara et al* fails to teach the refractory metal film as required by Claims 8 and 18. These claims recite a refractory metal film of W, Ta or Mo. In contrast, *Ishihara et al* merely discloses the use of Ti. Lastly, dependent Claims 5, 6, 8, 15, 16 and 18 would not be obvious at least for the reasons cited above in that the combined teachings of the cited references do not render obvious independent Claims 1, 9, 10 and 19.

For these reasons, Appellants respectfully submit that the dependent Claims 5, 6, 8, 15, 16 and 18 are separately patentable over the combined teachings of the cited references.

IX. CONCLUSION

For the foregoing reasons, Appellants respectfully submit that the rejections posed by the Examiner are improper as a matter of law and fact. Accordingly, Appellants respectfully request the Board reverse the rejections of Claims 1-19.

Respectfully submitted,



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on August 19, 1999.



Michael R. Huff